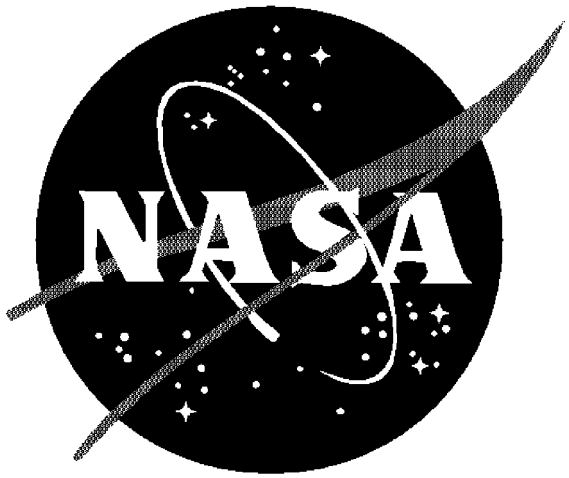

National Aeronautics and Space Administration

October 5, 2000

NRA-00-OES-09

RESEARCH ANNOUNCEMENT

INVESTIGATIONS THAT CONTRIBUTE TO THE NASA EARTH SCIENCE ENTERPRISE'S ATMOSPHERIC CHEMISTRY MODELING AND DATA ANALYSIS RESEARCH

Proposals Due November 27, 2000

OMB Approval No. 2700-0087

INVESTIGATIONS THAT CONTRIBUTE TO THE NASA EARTH SCIENCE ENTERPRISE'S ATMOSPHERIC CHEMISTRY MODELING AND DATA ANALYSIS RESEARCH

NASA Research Announcement
Soliciting Research Proposals
for
Period Ending
November 27, 2000

NRA 00-OES-09
Issued October 5, 2000

Office of Earth Science
National Aeronautics and Space Administration
Washington, DC 20546

NASA RESEARCH ANNOUNCEMENT

Investigations That Contribute to the NASA Earth Science Enterprise's Modeling and Data Analysis Research Supported by the Atmospheric Chemistry Modeling and Analysis Program, the Upper Atmosphere Research Satellite Mission, and the Total Ozone Mapping Spectrometer Satellite Mission

The NASA Earth Science Enterprise:

The mission of NASA's Earth Science Enterprise (ESE) is to develop a scientific understanding of the Earth system and its response to natural or human-induced changes, thereby improving the predictive capabilities for climate, stratospheric ozone, weather, and natural hazards. Through its science research programs, the ESE aims to acquire a deeper understanding of the components of the Earth system and their interactions. These interactions occur on a continuum of spatial and temporal scales ranging from local and regional to global scales and from short-term weather to long-term climate scales. The Enterprise also seeks to provide accurate assessments of changes in the chemical composition and physical state of the atmosphere; in the extent and health of the world's forest, grassland, and agricultural resources; and in geologic phenomena that lead to natural hazards.

The key research topics studied by NASA's Earth Science Enterprise fall largely into three categories: forcings, responses, and the processes that link the two and provide feedback mechanisms. This conceptual approach applies to all research areas of NASA's Earth Science program, although it is particularly relevant to the problem of climate change. The scientific strategy to address this complex problem can be laid out in five fundamental questions, each raising a wide range of cross-disciplinary science problems.

- *How is the global Earth system changing?*
- *What are the primary forcings of the Earth system?*
- *How does the Earth system respond to natural and human-induced changes?*
- *What are the consequences of change in the Earth system for human civilization?*
- *How well can we predict the changes to the Earth system that will take place in the future?*

While these five questions define a logical progression in the study of global change, each one covers a range of topics too broad to serve as a simple guide for program implementation. For this purpose, more specific research questions need to be formulated and prioritized.

The strength of NASA's Earth science program is derived from the synergy between different classes of observations, basic research, modeling, and data analysis, as well as field and laboratory studies. In particular, NASA's Earth Science research strategy recognizes the need for close linkage between the observation programs and the data analysis and predictive Earth system modeling programs at all relevant spatial and temporal scales. Developing the means for full utilization of global observational data (e.g. through systematic data assimilation) and for analysis of discrepancies between observed and modeled fields is considered an essential component of the program. In this respect, NASA's research strategy fully subscribes to the recommendation of the National Research Council's Board on Atmospheric Sciences and Climate (NRC, 1998) to: "Apply the discipline of forecasting… in order to advance knowledge, capabilities for prediction, and service to society". The synergy between global Earth observation, analysis, and modeling is perceived as an essential means to answer these scientific questions and as NASA's specific contribution to the U. S. Global Change Research Program.

The intellectual capital for both the planning and exploitation of Earth system observations is vested in a robust research and analysis program. Research and analysis is the conceptual source of Earth system science questions, and strategies to address them. The research program supports the early development of innovative observing techniques (including both instruments and the linkage of instruments with platforms) and processing algorithms, organizes field tests, and generally charts the path for scientific and engineering developments that enable future advances. It assures the linkage between global satellite observations, *in situ* process-oriented observations, and the computational models used to provide both a framework for interpretation of observations and a tool for prediction. It helps assure the development of consistent, integrated, and well calibrated data sets, especially those that involve multiple instruments, observational platforms, and observing techniques. Altogether, the research and analysis program brings fundamental research to bear on key Earth Science issues, and lays the interdisciplinary groundwork for linking these research efforts.

This NASA Research Announcement:

NASA is presently soliciting proposals for investigations that will contribute to modeling and data analysis research supported by its Earth Science Enterprise. This NRA specifically solicits proposals pertinent to the interests of disciplinary research and analysis and data analysis programs that include global and regional modeling activities and large-scale data analysis, especially model-driven analysis. It also solicits proposals from instrument science teams and/or guest investigators being newly competed or re-competed in which global and regional modeling and/or model-driven data analysis constitute major elements of the proposed work in the area of atmospheric chemistry and chemistry-climate interactions.

In keeping with overall NASA goals and those of the Office of Earth Science, research supported by this NRA will be directed toward demonstrating successful use of data from satellite observing systems, in conjunction with other kinds of data, to improve models

and data assimilations for the Earth system or one or more of its components. The five fundamental questions presented above are based on the importance of variability, forcing, response, consequences and prediction in Earth science. For the purposes of this NRA, more specific scientific questions within these categories have been identified as priorities:

- *How is stratospheric ozone changing as the abundance of ozone-destroying chemicals decreases?*
- *What trends in atmospheric constituents and solar radiation are driving global climate?*
- *How do stratospheric trace constituents respond to climate and chemical change?*
- *What are the effects of regional pollution on the global atmosphere, and the effects of global chemical and climate changes on regional air quality?*
- *To what extent can future atmospheric chemical impacts be assessed?*

Proposals that address one or more of these questions and help make the connection among variability, forcing, response, consequences, and prediction through the joint use of models and data are of particular interest. Where appropriate, priority will be given to proposals that illustrate the value of space-based remotely-sensed observations that contribute to our understanding of chemistry-climate interactions on the global scale. Research topics that accomplish this integration and are programmatically desirable at this time include (See Appendix A for more information and details):

Question 1: How is stratospheric ozone changing as the abundance of ozone-destroying chemicals decreases?

NASA has been mandated by Congress to document the variability and long-term changes in stratospheric ozone. A scientifically robust understanding of stratospheric ozone change and transient variations in ozone requires the analysis and modeling of accurate and consistent long-term observations of ozone distribution (both total column and vertical profiles), together with the key parameters governing its abundance. At this time, data sets of particular interest are from the Total Ozone Mapping Spectrometer (TOMS) and the Solar Backscatter Ultraviolet 2 (SBUV2) instrument, including comparison with appropriate ground- and balloon-based measurement networks (Dobson/Umkehr, ozonesondes, etc), and examinations of interconsistency with ozone measurements provided by various other space-based instruments such as the Stratospheric Aerosol and Gases Experiment (SAGE), Upper Atmosphere Research Satellite (UARS), Global Ozone Monitoring Experiment (GOME), etc.

Question 2: What trends in atmospheric constituents and solar radiation are driving global climate?

The primary external forcing affecting the Earth is change in the Sun's total energy output: therefore an accurate record of total solar irradiance is a necessary foundation for Earth system science. The Sun's energy output is considerably more variable in the ultraviolet part of the spectrum – ranging from some 5% over a solar cycle at the

wavelengths involved in stratospheric ozone production, to a factor 2 in the hydrogen Lyman alpha region of the spectrum that affects the mesosphere and thermosphere. The Upper Atmosphere Research Satellite (UARS) provides accurate measurements of the spectrum of solar irradiance in the ultraviolet (UV) region where absorption by ozone is the primary energy source for the stratosphere and the mesosphere. UARS also provides measurements of precipitating protons, electrons, and accompanying x-rays that may cause stratospheric and mesospheric constituent changes. To date, UARS measurements span about three quarters of an eleven year solar cycle, from the trailing edge of the last solar maximum (late 1991) through solar minimum (1996) to the beginning of the next solar maximum (present). These UARS data can be used to study short-term (days) to long-term (years) atmospheric variabilities caused by these energy inputs. These studies should have direct relevance to the troposphere, stratosphere or mesosphere.

Stratospheric aerosols that result from large volcanic eruptions can significantly cool the Earth's surface and warm the stratosphere, as has been demonstrated on several occasions. Tropospheric aerosols, on the other hand, can either cool or warm the atmosphere depending on their properties. Global observations of total aerosol amounts and stratospheric aerosol vertical profiles are required to monitor this important climate forcing globally and to inferring global surface ultraviolet fluxes. This is particularly evident from an examination of TOMS ozone, surface ultraviolet, and aerosol products. Hence, desired research in this category includes the analysis of the TOMS tropospheric aerosol product, including comparisons of TOMS-derived information on aerosol abundance with that from surface-, airborne-, balloon-, and other space-based instruments. Investigations focusing on aerosol distribution properties and photometric measurements are also included here. Studies which combine TOMS data with data from other space-based instruments such as the Stratospheric Aerosol and Gases Experiment (SAGE), Sea-viewing Wide Field-of-View Sensor (SeaWIFS), Moderate-Resolution Imaging Spectroradiometer (MODIS), Multi-angle Imaging Spectroradiometer (MISR), and Geoscience Laser Altimeter System (GLAS) are encouraged, as is the systematic comparison of aerosol products with models.

Long-lived trace gases such as carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons are all important for trapping infrared radiation in the atmosphere and contributing to global warming. The major observational requirement to monitor their total concentrations is *in situ* measurements of surface level concentrations of these trace gases, although the first measurements of the global distribution of total column methane are now becoming available from MOPITT on EOS Terra. Important studies are those directed at estimating the sources and sinks of these trace constituents at the surface of the Earth, making use of multi-dimensional atmospheric chemistry/transport models together with surface and, where available, space-based measurements of the spatial and temporal variations in trace gas concentrations.

Question 3: How do stratospheric trace constituents respond to climate and chemical change?

Climate change associated with increasing concentrations of trace gases will affect the distribution of ozone in the stratosphere, and vice versa. The connection between atmospheric temperatures and stratospheric composition is equally well established. A striking example is the enormous interannual variations in winter/spring ozone concentration over the Arctic, highly correlated with changes in stratospheric circulation and temperature driven by the troposphere. Long, cold winters, such as occurred in 1996-1997, enhance ozone destruction and make Arctic conditions more similar to those in the Antarctic that enable the large annual springtime depletion of ozone.

It has been suggested that climate change will affect the way in which the troposphere influences the stratosphere, and would thus indirectly affect stratospheric ozone. The impact would be particularly strong if the wintertime polar vortex became more stable. Similarly, chemical reactions that occur on the surface of stratospheric aerosol and/or cloud particles are temperature dependent; even a small decrease in temperature could cause a significant increase in the rates of these reactions. Changes in stratospheric water vapor, associated with changes in fluxes through the tropopause, could also enhance the formation of aerosol and cloud particles that facilitate ozone destruction. Furthermore, since ozone absorption of solar UV radiation causes stratospheric heating, a decrease in ozone amount would result in further cooling, and further accelerate ozone losses. There is already strong evidence of cooling in the lower stratosphere, which constitutes one of the largest temperature signals measured in the atmosphere over the past 20 years.

Improving our understanding of this highly interactive system calls for detailed investigation of the relationship between the distributions of ozone, water vapor, aerosols, temperature, and relevant trace constituents, notably chlorine and bromine compounds and nitrogen oxides. Therefore, joint modeling and data analysis studies of the dynamical, radiative, and chemical processes that couple the troposphere and the stratosphere, including those processes responsible for stratosphere-troposphere exchange, are considered a programmatic priority. Global data, such as that provided by UARS and TOMS, can be used to understand important radiative, dynamical, and chemical processes, however the analysis of higher resolution data, obtained from ground-based (e.g., lidar), aircraft, and balloons, is critical for some investigations, especially in the tropopause region.

Question 4: What are the effects of regional pollution on the global atmosphere, and the effects of global chemical and climate changes on regional air quality?

The continued growth of the world's population and increasing industrial development suggest that there will be increasing human impacts on the global atmosphere. As fossil fuel combustion increases, emissions of trace gases other than carbon dioxide will also rise, notably nitrogen oxides, carbon monoxide, hydrocarbons, and other precursors of ozone, as well as aerosol particles and their precursors.

Satellite observations provide evidence of the large-scale effects of such emissions on the troposphere. The highest tropospheric ozone concentrations observed in this way were found in summertime over mid-latitude regions of the northern hemisphere, and also over

the tropics in regions affected by biomass burning. Aircraft observations have demonstrated that plumes of pollution produced by fires can be transported thousands of kilometers to otherwise pristine regions of the atmosphere (e. g., over the Pacific Ocean). Surface level trace gas measurements made on the west coast of the United States show enhanced levels of ozone precursors during periods of rapid and direct transport of air from East Asia.

There are currently few space-based global observations of tropospheric ozone, key trace gases or aerosol particles and none provide nearly the required vertical resolution, although EOS Aura and future exploratory missions will greatly improve on this situation. Support for determination of tropospheric ozone distributions using TOMS, either together with other data sets, or independently based on assumptions about stratospheric ozone variations, is considered here. Critical evaluation of TOMS-derived tropospheric ozone distributions based on profiles from ozonesondes, lidars, etc. is desired. Other satellite data sets such as MOPITT, GOME, UARS, SAGE and ATMOS, along with data obtained from ground, balloon and aircraft observations, will also be considered. The consideration of the effects of global atmospheric change on the chemistry of the troposphere through the use of multi-dimensional atmospheric chemistry/transport models and the systematic comparison of models with observations of tropospheric ozone and its precursors are also a priority.

Question 5: To what extent can future atmospheric chemical impacts be assessed?

NASA's responsibilities include participation in national and international assessments, both in the troposphere and stratosphere. The Atmospheric Effects of Stratospheric Aircraft (AESA) component of the National Aeronautics and Space Administration (NASA) High Speed Research Program (HSRP) sought to assess the impact of a fleet of high-speed civil transport (HSCT) aircraft on the lower stratosphere. There were several components to their assessment work: laboratory and field measurements, characterization of the exhaust products, and development of realistic scenarios for the distribution of emissions. Models integrate information from the above efforts to calculate the fate of aircraft exhaust, the buildup of such pollution in the lower stratosphere, and the model response of ozone to the change in lower stratospheric composition. The use of models is thus a key element of the assessment, as models are the primary tools through which the impact on the ozone layer is quantified.

ESE has been tasked and funded to maintain some aspects of this assessment activity, and has decided that the Global Modeling Initiative (GMI) will be an important assessment and model evaluation tool in those efforts. The GMI model is a modular chemical-transport model (CTM) with the ability to carry out multiyear assessment simulations as well as incorporate different modules, such as meteorological fields, chemical mechanisms, numerical methods, and others representing the different approaches of current models. Research is being requested that contributes to model development and in the analysis of the observations within the GMI framework. Some principal investigators funded under this NRA may be encouraged to provide to GMI developed module, data set or analysis tool which can contribute to the overall assessment goal.

Provision of a module carries with it the explicit expectation of oversight in integration of the module into the GMI framework, evaluation of module performance, and, where relevant, evaluation of the sensitivity of that module to other processes in the GMI configuration. Future performance of these activities, if needed for assessment purposes, will be funded by either a redirection or increment in the Principal Investigator's funding.

The modeling and data analysis research proposals solicited by this NRA will be funded with resources designated for the Atmospheric Chemistry Modeling and Analysis Program (ACMAP), the Upper Atmosphere Research Satellite (UARS) Mission, and the Total Ozone Mapping Spectrometer (TOMS) Satellite Instrument Team, as well as a new initiative within ESE that takes charge of what was historically covered under the Atmospheric Effects of Aviation Project in the Office of Aero-Space Technology. Proposals are encouraged to address the needs of more than one of these three program areas, consistent with the objectives detailed in Appendix A.

Proposals should also meet the other requirements that are listed in Appendices B through D. Awards will be made for periods of up to three years to projects that are approved under the terms of this announcement. Funding for this NRA has not yet been appropriated and NASA reserves the right to cancel this NRA in the event that adequate funds are not appropriated. However, for planning purposes, we are anticipating a total of approximately $6.0 M per year associated with this requested research, with most tasks selected in the $75,000 - $150,000 range.

Participation is open to all categories of domestic and foreign organizations, including educational institutions, industry, non-profit institutions, NASA Centers, and other U.S. Agencies. In accordance with NASA Policy as described in Appendix B, all investigations by foreign participants will be conducted on a no-exchange-of-funds basis, i.e., investigators whose home institution is outside of the United States cannot be funded by NASA. Proposals may be submitted at any time during the period ending November 27, 2000, 4:30 PM EDT. NASA reserves the optional right to consider proposals received after that date in accordance with Appendix B, i.e., "the selecting official deems the late proposal to offer significant technical advantage or cost reduction". Proposals will be submitted to a peer and/or Program Office review and evaluation. Selected proposals will be announced during January/February 2001.

Technical information contained in Appendix A applies to this Research Announcement only. Appendices B through D contain NASA general guidelines for the preparation of proposals solicited by this Research Announcement.

Identifier **NRA-00-OES- 09**

Submit proposals to:
NASA Peer Review Services
500 E Street SW, Suite 200
Washington, DC 20024, USA
Phone: 202-479-9030

Number of Copies Required: 10

Selecting Official:
Director, Research Division
Office of Earth Science
NASA Headquarters

Obtain Additional Information From:

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Please use identifier number NRA-00-OES-09 when making an inquiry regarding this Announcement. Your interest and cooperation in participating in this opportunity are appreciated.

ORIGINAL SIGNED BY

Ghassem R. Asrar
Associate Administrator
Office of Earth Science

APPENDIX A

Technical Description and Specific Guidelines for this NRA

1. NASA Programmatic Areas Included in this NRA

a. Atmospheric Chemistry Modeling and Analysis Program (ACMAP):

The primary objective of the ACMAP is to study the distribution of trace constituents in the global troposphere and stratosphere through the use of computational models and through the analysis of spatially and temporally extended data sets. The ACMAP also supports the bulk of NASA's studies of stratospheric meteorology and of the dynamical, chemical, and radiative couplings between the Earth's stratosphere and troposphere, as well as between the stratosphere and upper atmosphere (mesosphere/thermosphere). Efforts within the ACMAP emphasize the global atmosphere, although some consideration is given to the large regional (continental and hemispheric) scales; the ACMAP does not support studies at local scales. Note that this program only supports proposals in the areas of data analysis, interpretation, and modeling; it does not support proposals for laboratory work or field measurements.

Current research in the ACMAP may be broken down into several categories as follows:

- *Stratospheric Dynamics and Related Data Analysis:* This includes modeling and data analysis studies of temperature and wind distributions in the stratosphere, transport processes in the stratosphere and their long-term evolution, as well as dynamical couplings between the stratosphere and regions below (troposphere) and above (mesosphere).

- *Atmospheric Chemistry Data Analysis:* This research area includes the analysis/re-analysis of new/existing satellite and other field measurement data on the trace constituent composition of the troposphere and stratosphere, including both short- and long-term variations. Data sets of greatest interest are NASA satellite missions and atmospherically-oriented aircraft missions (such as the stratospheric and upper tropospheric oriented AAOE, AASE I, AASE II, SPADE, ASHOE/MAESA, STRAT, VOTE/TOTE, POLARIS, and SOLVE and the tropospheric oriented GTE series of campaigns, as well as missions supported by NASA's Atmospheric Effects of Aviation Project, such as SUCCESS and SONEX). Investigations utilizing non-NASA space-based data, such as GOME, Polar Ozone and Aerosol Measurement (POAM), Ultraviolet Visible Imagers and Spectrographic Imagers/Midcourse Space Experiment (UVISI/MSX), etc., are of interest as well.

- *Aerosols, Stratospheric Clouds, and Radiation:* Studies of the combined physical and chemical processes by which aerosols and polar stratospheric clouds form in the atmosphere are a principal focus in this area. Also included are studies of the optical

and chemical effects such aerosols have on radiative transfer in the troposphere-stratosphere system, including ultraviolet radiation at the Earth's surface

- *Multi-Dimensional Atmospheric Modeling:* This area highlights studies of tropospheric and stratospheric chemistry using two- and three-dimensional models, emphasizing the simulation of the combined effects of chemical and transport properties on atmospheric chemistry. The evaluation of models using ground-, aircraft-, balloon-, and space-based data forms an important part of these efforts. Increasing emphasis has recently been placed on the improved representation of the chemical effects of aerosols on tropospheric trace constituents. Some consideration is given to the combined effects of atmospheric chemistry and climate change.

The ACMAP is one of several NASA programs supporting modeling and analysis of atmospheric trace constituents. Other NASA programs active in this area include the Interdisciplinary Science Program of the Earth Observing System (EOS), the Upper Atmosphere Research Satellite (UARS) Guest Investigator Program, and the UARS, Total Ozone Mapping Spectrometer (TOMS) and the Stratospheric Aerosol and Gas Experiment (SAGE II) Science Teams. Some process scale modeling activities are also carried out under the Upper Atmosphere Research Program and the Tropospheric Chemistry Program of OES. The research supported by the ACMAP contributes significantly to several elements of the Stratospheric Processes and their Role in Climate (SPARC) program of the World Climate Research Program and the International Global Atmospheric Chemistry (IGAC) program of the International Geosphere-Biosphere Programme (IGBP).

The full range of NASA's research in the area of atmospheric ozone, including plans for the future evolution of this research, is described in the Atmospheric Chemistry, Aerosols, and Solar Radiation section of the NASA OES *Science Implementation Plan*. This document will be available electronically at http://www.earth.nasa.gov/ in the near future. The broader context of NASA's Earth Science Enterprise program may be found in the *Earth Science Strategic Enterprise Plan*, which is available at http://www.earth.nasa.gov/visions/stratplan/index.html.

Via this NRA, the ACMAP intends to maintain support in each of the above areas, and submission of new or renewal proposals in any of them is invited. However, the research areas for which new and/or redirected renewal proposals are most desired at the present time are as follows:

- The study of the dynamical, radiative, and chemical processes that couple the troposphere and the stratosphere, including those processes responsible for stratosphere-troposphere exchange - Proposals that address the transport of trace constituents across the tropopause, (including hemispheric, seasonal, and interannual variation in cross-tropopause fluxes) are especially encouraged, as are proposals that address how the coupling between the troposphere and stratosphere might be expected to change in response to global atmospheric chemical and climate change.

Proposals that combine the use of atmospheric models with analysis of NASA-produced data sets are of particular interest (Question 3 and 5).

- The consideration of the effects of global atmospheric change on the chemistry of the troposphere through the use of multi-dimensional atmospheric chemistry/transport models - The background changes of greatest interest are global climate change and global chemical change; however, changes in land cover or land use that could have implications for global tropospheric chemistry are also of interest. Potential changes in all levels of the troposphere may be proposed in this area. Proposals should be global or near-global in scope; proposals focused on limited geographical regions are of much less interest than those at larger spatial scales. Proposals that combine the use of models with data sets, or explain how model results can be tested with data likely to be available are particularly encouraged (Questions 2, 4 and 5).

- Incorporation of multi-dimensional models, satellite data, and meteorological forecasting and analysis capabilities into multi-national and/or multi-agency field campaigns, especially airborne experiments, focused on improving our understanding of the chemistry of the free troposphere and/or stratosphere - The development of computational models to be used in this work should not be proposed here; it is expected that any proposals offered in this area will come from groups with models at an appropriate stage of development (Questions 2, 3, 4 and 5).

- Use of the Global Modeling Initiative (GMI) to provide a model framework for process algorithm intercomparisons - ACMAP has adopted the GMI as an important assessment and model evaluation tool following the successful application of the GMI approach to assessments of the atmospheric impact of aviation. The GMI model is a modular chemical-transport model (CTM) with the ability to carry out multiyear assessment simulations as well as incorporate different modules, such as meteorological fields, chemical mechanisms, numerical methods, and others representing the different approaches of current models. This capability facilitates the understanding of the differences and uncertainties of model results. A brief description of the GMI is given in Considine et al., (2000), Douglass et al., (1999), Kawa et al., (1999), Kinnison et al., (2000), Park et al., (1999), and Rotman et al., (2000). In order to fulfill these roles, the GMI must have the support and collaboration of the larger scientific community, both in terms of model development and in the analysis of the observations. In addition to augmenting and enhancing the ACMAP modeling efforts, it is expected that the GMI effort within ACMAP will provide ongoing benefit to assessing aircraft impacts to the atmosphere, particularly those potential impacts of the growing subsonic fleet on climate. Examples of important priorities include, but are not limited to (Questions 1, 2, 3, 4, and 5):

    1. Understanding the sensitivity of model results to the model's horizontal and vertical resolution, as well as the gridding of emissions near the tropopause region.

2. Coupling with climate models. This interaction involves a two-way collaboration between climate models and the GMI: climate models will supply the GMI with state-of-the-art simulations for past, current and future atmosphere, which will allow the GMI to incorporate the effects climate change on the stratospheric and tropospheric chemistry and transport. The GMI, in turn, will provide climate models with changes in the present abundances of radiatively active species (e.g., gases and aerosols) expected for different scenarios.

3. Better characterization and calculation of tropospheric chemistry. Examples of outstanding issues are our developing understanding of the chemistry of the upper troposphere, incorporation and testing of heterogeneous tropospheric chemistry, and development of accurate and efficient numerical solvers for the chemical and radiative calculations.

4. Continued improvements in processes not explicitly resolved by the CTM: Such processes include our representation of convection and wet scavenging, boundary layers, or cloud processing.

5. Better characterization of natural and anthropogenic emissions, such as the production of NO_x by lightning, and surface emissions of reactive compounds (NO_x, CO, VOC) from both anthropogenic and biogenic sources.

6. Stratosphere-troposphere interactions: This includes development of a coupled stratosphere-troposphere model with chemical mechanisms appropriate for both regions, addressing stratosphere-troposphere photochemical feedbacks; understand the model characteristics (numerical, meteorological) controlling the fluxes of O_3, NO_y, and other key species between the stratosphere and the troposphere.

7. Improvement and testing of the stratospheric component of the GMI: Work in this area includes a better treatment of heterogeneous and polar processes. Examples are: (i) more detailed treatment of PSCs, (ii) comparison of model-calculated ozone trends to those observed during the last two decades, (iii) simulation of future ozone changes (both polar and mid-latitude) with their feedback on the circulation and temperature of the stratosphere, (iv) inclusion of improved meteorological fields from different general circulation models that give better simulations of the present-day stratosphere, and (v) expanded comparison of results with atmospheric measurements.

8. Continued development of aerosol microphysical modules. Some immediate and long-term needs include increasing the resolution of aerosol sizes in the current module, and incorporation of the microphysics and chemistry for the wide range of aerosol compositions encountered in the troposphere.

9. Model evaluation. This involves collection of an appropriate database of atmospheric measurements along with the specifications (e.g., emissions,

boundary conditions) for an appropriate CTM simulation of these results, particularly those data that test isolated processes in the model. This evaluation also includes comparison of GMI results to those of other models and understanding of the differences.

10. Development of modules that will eventually enable a calculation of perturbations to contrails and cirrus clouds. Such modules will focus on development of aerosol models for the upper troposphere, particularly those particles that can seed ice clouds and depend on progress in development of process models for contrail and cirrus formation. Changes in cirrus clouds cannot be evaluated without considering feedbacks on the hydrologic cycle of the upper troposphere and hence require coupling of GMI aerosol-chemistry modules with a GCM.

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Rotman, D., D. Bergmann, P. Connell, R. Kawa, D. Kinnison, S. Lin, M. Prather, D. Proctor, R. Ramaroson, P. Rasch, J. Rodriguez, R. Rood, J. Tannahill, (2000) The Global Modeling Initiative Assessment Model: Model description, integration ad testing of the transport shell, J. Geophys. Res., in press.

b. Upper Atmosphere Research Satellite (UARS) Science Team:

Individuals responding to this component of the NRA should propose data analysis and/or theoretical studies to be conducted as an Investigator for the UARS program. UARS observations are available to the public and are accessible through the Distributed Active Archive Center located at the Goddard Space Flight Center. Current observations are released to the DAAC monthly. In addition to the satellite data, some correlative data from balloon, aircraft, and ground-based platforms that are part of the UARS database are also available. Because, existing measurement networks provide adequate information for conducting validation and comparisons with UARS products, the UARS component of this NRA does not solicit additional experimental / field measurement investigations. Similarly, it does not solicit proposals for model development or proposals to acquire data handling facilities or computers. Investigators should utilize existing data analysis techniques and theoretical models in their proposed work and should have on hand the computing and communications facilities necessary for performing the proposed work. Since UARS is currently operating, Flight Operations for the satellite platform, instrument operations, algorithm maintenance, and program management are not included under the scope of this NRA and will be funded separately.

Technical Description

The Upper Atmosphere Research Satellite is an important NASA mission aimed at improving our knowledge and understanding of the atmosphere between about 15 and 100 km. (middle atmosphere, i.e., the earth's stratosphere, mesosphere, and lower thermosphere) in order to understand and better predict the response of this sensitive part of the earth system to natural changes and to changes resulting from human activities.

There has been increasing concern in recent years about the sensitivity of the Earth's atmosphere to external influences associated both with changing natural phenomena and changes arising from various human activities. Long-standing curiosity about atmospheric evolution and the factors influencing climate and weather has been heightened by the discovery of such phenomena as the Antarctic ozone hole and the buildup of trace gases in the atmosphere that could lead to global warming. These discoveries clearly indicate that human activities can lead to significant inadvertent atmospheric modification. Modifications are possible both in the lower and upper atmosphere, and can have enormous implications for the future of the planet. They highlight the need for a long-term program of scientific research directed toward improving knowledge of the physical and chemical processes occurring in the Earth's atmosphere.

The UARS is, thus, providing a focus for the resolution of key scientific questions relating to the chemistry, dynamics, and overall energy balance of these regions. Through a combination of measurements, theoretical studies of basic processes, and large-scale modeling, scientific progress is being made through the UARS program toward solving some of the outstanding physical and chemical problems of the upper atmosphere. Extensive theoretical activity, coupled to data and model analysis, is an

integral part of the program and has been since its inception. Highlights of advances made with UARS data are available on the UARS web site http://umpgal.gsfc.nasa.gov/.

The UARS was deployed on September 15, 1991 in a circular orbit at 600 km altitude and 57 degrees orbital inclination. The UARS Observatory contains 9 instruments (and an instrument of opportunity not specifically related to UARS objectives) that measure chemical composition, dynamics, and energy input in the form of solar ultraviolet radiation and energetic particle precipitation into the earth's upper atmosphere. The satellite was deployed on September 15, 1991 from the Space Shuttle Discovery, launched from the Kennedy Space Center on September 12, 1991. The observatory is in a circular orbit at 600 km and inclined 57 degrees with respect to the Equator. At this altitude and inclination the remote sensors that view the atmosphere at an angle of 90 degrees with respect to the spacecraft velocity vector can see to 80 degrees latitude, providing nearly global coverage. This inclination also produces a precession of the orbit plane such that all local solar times are sampled in about 36 days. The spacecraft is yawed 180 degrees approximately every 36 days, so that high latitude coverage alternates between north and south.

Although the UARS program was expected to last a few years, the satellite has now been operational for nine years, permitting science investigations beyond the scope of the original UARS goals. Applications that exploit all the aspects of the UARS data set are vital to the UARS extended mission.

The measurement capabilities of the 9 scientific instruments aboard UARS are described on the web site mentioned above. These measurements include solar irradiance at ultraviolet and visible wavelengths; X-ray, proton, and electron fluxes; temperature and constituents; and two-component wind vectors. The data are publicly available on the Distributed Active Archive Center (DAAC) at NASA Goddard Space Flight Center. Current and reprocessed data are transferred from the UARS Central Data Handling Facility (CDHF) to the DAAC at monthly intervals. For all instruments, except the two that measure the solar spectrum, the archived data are altitude profiles (Level 3-A). All users of the UARS data including investigators under this program should carefully examine quality flags on the UARS data sets. Responsibility for proper use of the data, including recognition of any limitations and potential errors rests with the investigator using the data. The instrument Principal Investigators should be contacted with questions concerning the current algorithm, future delivery of an improved algorithm, and anticipated improvements.

The UARS data can be ordered from the Goddard DAAC via their online browse system. The address for inquiries is

DAAC
User Services
Mail Code 902
NASA/Goddard Space Flight Center
Greenbelt, MD 20771

Phone 301-286-3209
Web Address: http://daac.gsfc.nasa.gov/DAAC_DOCS/gdaac_home.html

In addition to the UARS instrument data set, the United Kingdom Meteorological Office (UKMO) and the National Center for Environmental Protection (NCEP, formerly National Meteorological Center (NMC)) provide wind and temperatures fields for the UARS observing period which are available from the DAAC.

NASA also funded a UARS Correlative Measurements Program, which included ground based, balloon, aircraft, and shuttle observations. These data have been used by the instrument teams to validate the UARS observations (e.g., the Journal of Geophysical Research April 30,1996 special issue "Evaluation of the UARS Data"). Applicants interested in utilizing correlative data associated with a particular UARS instrument should contact the instrument PI for information on the type and availability of correlative data.

As of April 2000, seven of the UARS scientific instruments remain operational. The Improved Stratospheric and Mesospheric Sounder (ISAMS) experienced a chopper failure in July 1992 and has ceased retrieving atmospheric data. The Cryogenic Limb Array Etalon Spectrometer (CLAES) experienced cryogen depletion in May 1993, after completing its planned period of operations. The Microwave Limb Sounder (MLS) has two of three microwave channels working: the 183 GHz band, used to retrieve stratospheric water vapor, failed in April 1993. The other channels on the MLS are operational. However, there have been indications that the useful lifetime of MLS is nearing an end, and MLS has had limited observing time in the past year. It is currently planned to turn MLS on only every few months for the remainder of the UARS mission. The Particle Environment Monitor (PEM) instrument has experienced failures (October 1991 and May 1999) and degradations (June 1994 and November 1998) in all of its low-energy proton sensors (<35 keV); however, its proton sensors detecting energies greater than 35 keV remain operational as well as its electron and X-ray channels. All other instruments are fully operational.

As a result of problems with the satellite solar array drive, UARS has been operating since March 1995 with less power than is required to operate all of the instruments simultaneously. UARS experienced a further reduction in power in June1997 with the loss of one of three batteries. In October 1999, the UARS experienced difficulties with its remaining tape recorder. Use of only 25% of a tape recorder is now possible and the UARS is in a "real-time" operation through communication using two Tracking and Data Relay Satellites (TDRS's). The two TDRS's allow capture of about 50-55% of the measurements in a given orbit. The priority instruments in the reduced power and power-sharing mode are the Halogen Occultation Experiment (HALOE), the Solar Stellar Intercomparison Experiment (SOLSTICE), and Solar Ultraviolet Spectral Irradiance Monitor (SUSIM). Other instruments are operated as the available power allows. Power is plentiful during the "day" part of the UARS orbit and two instruments (the High Resolution Doppler Imager (HRDI) and the PEM) take advantage of this situation by also operating in a "daytime-only" mode.

The reduced observing schedule limits some studies, but provides information necessary for the extended goals of the UARS mission. These goals include process studies, constituent trends, solar UV and particle measurements through a solar cycle, and observations of dynamic variability on semiannual, biannual, and longer time scales.

Possible Proposal Areas

Investigations are solicited by this Research Announcement in all areas within the scientific scope of the UARS program, with particular emphasis on the extended mission goals. Examples of the kinds of studies that could be supported within the UARS program are given below.

- Responses to Energy Inputs - UARS provides accurate measurements of the spectrum of solar irradiance in the ultraviolet (UV) region where absorption by ozone is the primary energy source for the stratosphere and the mesosphere. UARS also provides measurements of precipitating protons, electrons, and accompanying x-rays that may cause stratospheric and mesospheric constituent changes. To date, UARS measurements span more than three quarters of an eleven year solar cycle, from the trailing edge of the last solar maximum (late 1991) through solar minimum (1996) to the beginning of the next solar maximum (present). These UARS data can be used to study short-term (days) to long-term (years) atmospheric variabilities caused by these energy inputs. These studies should have direct relevance to the troposphere, stratosphere or mesosphere. Studies that "cross platforms" (i.e., that tie solar variations to variations in ozone and other trace gases abundances) are of particular interest. (Questions 1, 2, 3, and 5)

- Dynamics - Direct wind measurements on UARS provide a unique opportunity to study the dynamics of the middle atmosphere. Long term observations of winds in the stratosphere and mesosphere provide a basis for studying motion of varying time scales, and can be related in some cases to measurements of long-lived gases which are tracers of atmospheric motion. The global data that UARS is providing can be used to understand important radiative, dynamical, and chemical processes occurring in the middle atmosphere. These data can provide critical comparisons with global model simulations. Studies of the variation in dynamics over a solar cycle, or the study of quasi-periodic phenomena such as the Quasi-Biennial Oscillation (and even El Niño) are of interest. (Questions 1, 3, and 5)

- Middle Atmospheric Ozone - The middle atmosphere constituents changed noticeably during the nine years of UARS observations. Some of these changes included transport variations, anthropogenically-induced forcings, solar cycle UV fluctuations, sulfate aerosol densities, and the onset and geographic extent of polar stratospheric clouds. UARS measures the concentrations of a number of long-lived, reservoir, and radical gases that are important in controlling ozone. UARS also provides information on the evolution of the sulfate aerosol layer and polar stratospheric clouds, both of which are important in the regulation of many stratospheric

constituents including ozone. These measurements, combined with other UARS observations of energy inputs (including UV radiation), computations of transport, and observations of temperature, can be used to test the general theoretical understanding of ozone in the middle atmosphere. Comparison of the ensemble of the several years of UARS measurements of radicals, reservoirs, and long-lived species with model values provide very rigorous tests of model chemistry and transport. (Questions 1, 3, and 5)

Proposals for investigations are welcome in all of these areas. Proposals in other areas of the UARS program science are also welcome, although priority will be given to those investigations dealing with the middle atmosphere. Proposers should show how their investigation relates to the goal of UARS, which is to obtain improved understanding of the chemistry, dynamics, and energy input into the Earth's atmospheric layers and the coupling among them.

c. Total Ozone Mapping Spectrometer Science Team:

Individuals responding to this component of the NRA should propose data analysis, theoretical, and/or measurement studies to be conducted as an Investigator for the TOMS program. The TOMS instrument is a six-channel ultraviolet instrument, which was designed to use the backscatter ultraviolet (BUV) technique to determine the total column amount of ozone in the atmosphere using six wavelengths. TOMS has been at the forefront of NASA's space-based ozone measurement program with the flight of TOMS instruments aboard NASA's Nimbus 7 satellite (1978 to 1993), a Russian Meteor-3M satellite (1991-1994), the Japanese Advanced Earth Observing Satellite (ADEOS) (1996 – 1997), and NASA's Earth Probe spacecraft (1996 – present). In addition to its information on total ozone, the TOMS instruments have been shown to provide information on atmospheric sulfur dioxide abundances following large volcanic eruptions, the distribution of ultraviolet absorbing aerosols and volcanic ash in the troposphere, the flux of ultraviolet radiation incident at the Earth's surface, and, either together with data from other satellites or based on some assumptions about the distribution of stratospheric ozone, on the distribution of ozone in the troposphere.

TOMS data are recorded on the spacecraft and then downlinked and transmitted to the TOMS Science Operations Center at the Goddard Space Flight Center for rapid processing. In most cases, ozone values are mapped and made available as they are received (within hours), and full global maps are usually available within 36 hours. These data (along with the historical data sets) are available electronically on the TOMS home page http://toms.gsfc.nasa.gov. Both numerical values of the ozone fields as well as color images (full globe, North Polar projection, and South Polar projection) are available. Data on the other TOMS products (aerosols, reflectivity, and erythemal UV) can also be obtained from this site. Since TOMS is currently operating, Flight Operations for the satellite platform, instrument operations, algorithm maintenance, and program management are not included under the scope of this NRA and will be funded separately.

Technical Description

The currently operating TOMS instrument (on NASA's Earth Probe (EP) satellite) was launched on July 2, 1996 into a 500 km sun-synchronous orbit in order to provide improved horizontal resolution for its measurements of aerosol sources (26 km x 26 km at nadir compared to the 42 km x 42 km resolution of ADEOS). As a result Earth Probe TOMS did not provide full inter-orbit coverage at latitudes lower than 60 degrees. This two TOMS strategy was adopted to provide both high spatial resolution and daily global coverage. With the failure of the Japanese ADEOS satellite, the orbit of EP was boosted to 740 km and circularized to provide coverage that is as complete as possible. As with the pre-boosted measurements, the EP-TOMS data still has missing elements at the equator, but these do not present a significant problem in analysis.

The ADEOS and Earth Probe TOMS instruments were significantly modified from the previous TOMS instruments, with increased in-flight calibration capability, changes in several of the wavelengths used in the actual measurement, and modified electronics to provide interfaces with the different spacecraft.

A new TOMS instrument (QuikTOMS) is scheduled for launch in mid-2001. This mission has been designed to continue the current EP TOMS measurements.

A brief description of the various TOMS data sets follows:

- TOMS measures the sulfur dioxide (SO_2) column following large volcanic eruptions and a significant record of observations of volcanic SO_2 has been built up over the years. Images of volcanic sulfur dioxide and ash plumes are available electronically at http://skye.gsfc.nasa.gov.

- Volcanic ash plumes in the troposphere have also been observed with TOMS instruments. Typically, these plumes can only be observed for a few days before their dispersal.

- The TOMS instruments also obtain information on tropospheric aerosols. These measurements make use of the wavelength dependence of UV reflectivity measured at channels, which are little affected by ozone. In the earlier TOMS instruments, there were several such channels; in particular, the 331.3, 360 and 380 nm channels provided excellent long-wavelength information. Although the 380 nm channel was eliminated in the new TOMS instruments, tropospheric aerosol measurements are still possible using the 360 nm and 331.3 nm channels. TOMS can clearly observe UV-absorbing materials such as mineral desert dust, volcanic ash, and smoke from fires.

- The average flux of ultraviolet radiation at the Earth's surface can also be determined from TOMS. Knowing the solar flux entering the atmosphere (determined using spectrally-resolved solar irradiance data from instruments aboard NASA's Upper Atmosphere Research Satellite), the total ozone measured from TOMS, and information on cloud and aerosol cover provided by the long wavelength TOMS

channels, radiative transfer models can accurately estimate the amount of ultraviolet radiation reaching the surface. This technique was validated by comparison with ground-based measurements made in Toronto and shown to have information on trends over most of the Earth.

- TOMS has also been used to determine the first surface reflectivity climatology of the Earth's surface (oceans and land) in the near UV.

- Although tropospheric ozone cannot be directly measured by TOMS, information on its distribution can be obtained by subtracting stratospheric ozone as measured by some other instrument (i.e., the Stratospheric Aerosol and Gas Experiment (SAGE II), Solar Backscatter Ultraviolet (SBUV/2), Halogen Occultation Experiment (HALOE) or Microwave Limb Sounder (MLS)) from the TOMS total column. This is the so-called tropospheric ozone residual (TOR) technique. Tropospheric ozone can also be derived directly from TOMS by making some assumption about the variation of stratospheric ozone.

Science teams were originally established for these TOMS instruments based on the principal investigators and co-investigators on the proposals submitted for each instrument, as well as subsequent changes approved by NASA. Given the long time period between selection and launch, however, a decision was made in 1997 to re-compete the science teams and to establish a single unified science team for all TOMS instruments. The current NRA repeats this re-competition. Because of the commonality between the TOMS instruments and the Solar Backscatter Ultraviolet series of instruments (SBUV/2), investigators selected for the TOMS science team may also carry out appropriate investigations relevant to SBUV/2. Like TOMS, SBUV/2 uses the backscatter ultraviolet technique to obtain information on total column ozone amounts (with much reduced spatial coverage than TOMS because it does not do cross-track scanning), but it also provides information on the vertical profile of ozone, especially in the middle and upper stratosphere.

Possible Proposal Areas

Investigations are solicited by this Research Announcement in all areas within the scientific scope of the TOMS program. However, proposals in one or more of the following four major areas of research are particularly desirable.

- TOMS/SBUV Validation - Proposals in this research area should address the validation of TOMS products under difficult observing conditions. These include heavy aerosol loading (smoke and dust), moderate to heavy clouds, and very high solar zenith angles. Existing ground-based networks do not provide adequate information to validate the TOMS products under these difficult conditions. However, many new TOMS products, such as tropospheric ozone, require that the algorithm perform well under some of these conditions. Support would be provided for a limited number of measurements designed for comparison with TOMS data. This would be for focused comparisons, and should not be used to support existing

networks unless specific measurements are required for TOMS validation. This is the only category of TOMS Science Team activity for which support of field measurements will be considered. (Questions 1, 2, 3, 4, and 5)

- TOMS/SBUV Trend Studies - This research area focuses on the analyses of long-term data sets on total column ozone amounts (TOMS, SBUV/2) and ozone vertical profile measurements (SBUV/2), including comparison with appropriate ground- and balloon-based measurement networks (Dobson/Umkehr, ozonesondes, etc). A major focus of such research should include cross-instrument studies, and examinations of interconsistency between ozone measurements provided by various space-based instruments. Studies of the detailed relationships of instrument performance to retrieved ozone distributions are important in this category. (Questions 1, 2, 3, 4, and 5)

- Tropospheric Aerosols - Included in this category is the analysis of the TOMS tropospheric aerosol product, including comparisons of TOMS-derived information on aerosol abundance with that from surface-, airborne-, balloon-, and space-based instruments. Investigations focusing on aerosol distribution properties and photometric measurements are also included here. Studies which combine TOMS data with data from other space-based instruments, such as the Sea-viewing Wide Field-of-View Sensor (SeaWIFS), Moderate-Resolution Imaging Spectroradiometer (MODIS), Multi-angle Imaging Spectroradiometer (MISR), and Geoscience Laser Altimeter System (GLAS), etc., are encouraged, as is the systematic comparison of aerosol products with models. (Questions 2, 3, 4, and 5)

- Tropospheric Ozone - Support for determination of tropospheric ozone distributions using TOMS, either together with other data sets, or independently based on assumptions about stratospheric ozone variations, is considered here. Combining TOMS data with other satellite data sets, such as MOPITT will also be considered. Critical evaluation of TOMS-derived tropospheric ozone distributions based on profiles from ozonesondes, lidars, etc. and comparison with models is desired. The systematic comparison of tropospheric ozone products with models is also a priority. (Questions 2, 4, and 5)

Proposals in other areas will also be considered, including: (i) the development of techniques to improve existing TOMS products, (ii) the development of new products, such as actinic flux, (iii) innovative applications of TOMS data, such as in the derivation of upper air winds from total ozone maps to improve weather forecasts, and (iv) laboratory or in-situ measurement of aerosol absorption at TOMS wavelengths.

2. Guidelines for Proposers

General instructions for submission of a proposal in response to this announcement are given in Appendix B. **Please note carefully** that in addition to the requirements of

Appendix B, and any specific requirements in the relevant program sections above, proposals should provide the following information:

- Respondents interested in participation in the TOMS, UARS or GMI science teams should explicitly indicate such an interest. A proposal may be applicable to more than one of the three areas. In each case, a brief statement of the relevancy for the selected area should be included on the abstract page.

- A proposal that the cognizant program manager determines is not relevant to the programmatic interests listed in Appendix A will be returned to the proposer.

- A work plan indicating the specific tasks that are planned for each year of the proposed project should be included.

- All proposals should include a list of other support for the principal investigator and any co-investigators. Where the proposers have other support from NASA's Office of Earth Science, a clear statement of the relationship between this proposal and their other NASA funding should be provided.

- Vitae for each investigator should be limited to no more than three pages, including a selected list of publications.

- To facilitate recycling, proposals should be prepared on white paper using no binding material other than clips or staples. No plastic cover sheets should be used. If color figures are used, proposers should assure that all proposal copies contain color copies of the figures.

- If use of NASA supercomputer resources is anticipated, an estimate of computational requirements on a NASA system should be included as part of the budget submission.

- Costs for acquisition, storage, or processing of data should be included as well as for any required ancillary or *in situ* data. If data are desired that could be made available through the "data buy" activity of NASA's Commercial Remote Sensing Program (CRSP), this should be clearly stated. NASA's policy is to work cooperatively with other U.S. government agencies and our international partners in the development of a comprehensive capability to observe and understand the Earth. In addition, both National and NASA policy require NASA to support private-sector investment in commercial space activities by committing the U.S. government to purchase commercially available goods and services. NASA will not develop a mission that in any significant way competes with or duplicates planned commercial capabilities.

  NASA's Earth Science Enterprise has adopted commercial data purchases as a mainstream way of acquiring research-quality data, as these commercial capabilities become available. NASA encourages the use of commercially available data sets by Principal Investigators as long as it meets the scientific requirements and is cost-

effective. When responding to a NASA Research Announcement the proposer should identify the commercial data sources intended for use and the associated cost.

- To insure adequate communications between investigators in the component programs, proposers should include in their plans one three-day program review or Science Team meeting each year (two for GMI). For budget purposes, assume that these meetings will alternate between East and West Coast locations.

Proposers are requested to be reasonably concise when writing a proposal. The expository text, exclusive of references, vitae, budget information, and certifications, should not exceed 15 pages of single-spaced pica 12 type. Proposals should be self-contained and should not make unnecessary references to other materials.

Review of submitted proposals will be competitive and conducted as described in Appendix B. The responsible Program Manager reserves the right to negotiate revised budgets and/or work plans in light of the results of the review process. Funding will typically be in annual installments for a period of three years, subject to demonstrated satisfactory progress and continued availability of funds. Funding of successful proposals is expected to start early in fiscal year 2001.

APPENDIX B

INSTRUCTIONS FOR RESPONDING TO NASA RESEARCH ANNOUNCEMENTS

NASA Federal Acquisition Regulation (FAR), Supplement (NFS) Part 1852.235-72 , Effective JANUARY 2000 (Modified)

(a) **General.**

(1) Proposals received in response to a NASA Research Announcement (NRA) will be used only for evaluation purposes. NASA does not allow a proposal, the contents of which are not available without restriction from another source, or any unique ideas submitted in response to an NRA to be used as the basis of a solicitation or in negotiation with other organizations, nor is a pre-award synopsis published for individual proposals.

(2) A solicited proposal that results in a NASA award becomes part of the record of that transaction and may be available to the public on specific request; however, information or material that NASA and the awardee mutually agree to be of a privileged nature will be held in confidence to the extent permitted by law, including the Freedom of Information Act.

(3) NRAs contain programmatic information and certain requirements which apply only to proposals prepared in response to that particular announcement. These instructions contain the general proposal preparation information which applies to responses to all NRAs.

(4) A contract, grant, cooperative agreement, or other agreement may be used to accomplish an effort funded in response to an NRA. NASA will determine the appropriate instrument. Contracts resulting from NRAs are subject to the Federal Acquisition Regulation and the NASA FAR Supplement. Any resultant grants or cooperative agreements will be awarded and administered in accordance with the NASA Grant and Cooperative Agreement Handbook (NPG 5800.1).

(5) NASA does not have mandatory forms or formats for responses to NRAs; however, it is requested that proposals conform to the guidelines in these instructions. NASA may accept proposals without discussion; hence, proposals should initially be as complete as possible and be submitted on the proposers' most favorable terms.

(6) To be considered for award, a submission must, at a minimum, present a specific project within the areas delineated by the NRA; contain sufficient technical and cost information to permit a meaningful evaluation; be signed by an official authorized to legally bind the submitting organization; not merely offer to perform standard services or to just provide computer facilities or services; and not significantly duplicate a more specific current or pending NASA solicitation.

(b) **NRA-Specific Items.** Several proposal submission items appear in the NRA itself: the unique NRA identifier; when to submit proposals; where to send proposals; number of copies required; and sources for more information. Items included in these instructions may be supplemented by the NRA.

(c) The following information is needed to permit consideration in an objective manner. NRAs will generally specify topics for which additional information or greater detail is

desirable. Each proposal copy shall contain all submitted material, including a copy of the transmittal letter if it contains substantive information.

(1) **Transmittal Letter or Prefatory Material.**

(i) The legal name and address of the organization and specific division or campus identification if part of a larger organization;

(ii) A brief, scientifically valid project title intelligible to a scientifically literate reader and suitable for use in the public press;

(iii) Type of organization: e.g., profit, nonprofit, educational, small business, minority, women-owned, etc.;

(iv) Name and telephone number of the principal investigator and business personnel who may be contacted during evaluation or negotiation;

(v) Identification of other organizations that are currently evaluating a proposal for the same efforts;

(vi) Identification of the NRA, by number and title, to which the proposal is responding;

(vii) Dollar amount requested, desired starting date, and duration of project;

(viii) Date of submission; and

(ix) Signature of a responsible official or authorized representative of the organization, or any other person authorized to legally bind the organization (unless the signature appears on the proposal itself).

(2) **Restriction on Use and Disclosure of Proposal Information.** Information contained in proposals is used for evaluation purposes only. Offerors or quoters should, in order to maximize protection of trade secrets or other information that is confidential or privileged, place the following notice on the title page of the proposal and specify the information subject to the notice by inserting an appropriate identification in the notice. In any event, information contained in proposals will be protected to the extent permitted by law, but NASA assumes no liability for use and disclosure of information not made subject to the notice.

Notice
Restriction on Use and Disclosure of Proposal Information

The information (data) contained in *[insert page numbers or other identification]* of this proposal constitutes a trade secret and/or information that is commercial or financial and confidential or privileged. It is furnished to the Government in confidence with the understanding that it will not, without permission of the offeror, be used or disclosed other than for evaluation purposes; provided, however, that in the event a contract (or other agreement) is awarded on the basis of this proposal the Government shall have the right to use and disclose this information (data) to the extent provided in the contract (or other agreement). This restriction does not limit the Government's right to use or disclose this information (data) if obtained from another source without restriction.

(3) **Abstract.** Include a concise (200-300 word if not otherwise specified in the NRA) abstract describing the objective and the method of approach.

(4) **Project Description.**

(i) The main body of the proposal shall be a detailed statement of the work to be undertaken and should include objectives and expected significance; relation to the present state of knowledge; and relation to previous work done on the project and to related work in progress elsewhere. The statement should outline the plan of work, including the broad design of experiments to be undertaken and a description of experimental methods and procedures. The project description should address the evaluation factors in these instructions and any specific factors in the NRA. Any substantial collaboration with individuals not referred to in the budget or use of consultants should be described. Subcontracting significant portions of a research project is discouraged.

(ii) When it is expected that the effort will require more than one year, the proposal should cover the complete project to the extent that it can be reasonably anticipated. Principal emphasis should be on the first year of work, and the description should distinguish clearly between the first year's work and work planned for subsequent years.

(5) **Management Approach.** For large or complex efforts involving interactions among numerous individuals or other organizations, plans for distribution of responsibilities and arrangements for ensuring a coordinated effort should be described.

(6) **Personnel.** The principal investigator is responsible for supervision of the work and participates in the conduct of the research regardless of whether or not compensated under the award. A short biographical sketch of the principal investigator, a list of principal publications and any exceptional qualifications should be included. Omit social security number and other personal items which do not merit consideration in evaluation of the proposal. Give similar biographical information on other senior professional personnel who will be directly associated with the project. Give the names and titles of any other scientists and technical personnel associated substantially with the project in an advisory capacity. Universities should list the approximate number of students or other assistants, together with information as to their level of academic attainment. Any special industry-university cooperative arrangements should be described.

(7) **Facilities and Equipment.**

(i) Describe available facilities and major items of equipment especially adapted or suited to the proposed project, and any additional major equipment that will be required. Identify any Government-owned facilities, industrial plant equipment, or special tooling that are proposed for use. Include evidence of its availability and the cognizant Government points of contact.

(ii) Before requesting a major item of capital equipment, the proposer should determine if sharing or loan of equipment already within the organization is a feasible alternative. Where such arrangements cannot be made, the proposal should so state. The need for items that typically can be used for research and non-research purposes should be explained.

(8) **Proposed Costs (U.S. Proposals Only).**

(i) Proposals should contain cost and technical parts in one volume: do not use separate "confidential" salary pages. As applicable, include separate cost estimates for salaries and wages; fringe benefits; equipment; expendable materials and supplies; services; domestic and foreign travel; ADP expenses; publication or page charges; consultants; subcontracts; other miscellaneous identifiable direct costs; and indirect costs. List salaries and wages in appropriate organizational categories (e.g., principal investigator,

other scientific and engineering professionals, graduate students, research assistants, and technicians and other non-professional personnel). Estimate all staffing data in terms of staff-months or fractions of full-time.

(ii) Explanatory notes should accompany the cost proposal to provide identification and estimated cost of major capital equipment items to be acquired; purpose and estimated number and lengths of trips planned; basis for indirect cost computation (including date of most recent negotiation and cognizant agency); and clarification of other items in the cost proposal that are not self-evident. List estimated expenses as yearly requirements by major work phases.

(iii) Allowable costs are governed by FAR Part 31 and the NASA FAR Supplement Part 1831 (and OMB Circulars A-21 for educational institutions and A-122 for nonprofit organizations).

(iv) Use of NASA funds--NASA funding may not be used for foreign research efforts at any level, whether as a collaborator or a subcontract. The direct purchase of supplies and/or services, which do not constitute research, from non-U.S. sources by U.S. award recipients is permitted. Additionally, in accordance with the National Space Transportation Policy, use of a non-U.S. manufactured launch vehicle is permitted only on a no-exchange-of-funds basis.

(9) **Security.** Proposals should not contain security classified material. If the research requires access to or may generate security classified information, the submitter will be required to comply with Government security regulations.

(10) **Current Support.** For other current projects being conducted by the principal investigator, provide title of project, sponsoring agency, and ending date.

(11) **Special Matters.**

(i) Include any required statements of environmental impact of the research, human subject or animal care provisions, conflict of interest, or on such other topics as may be required by the nature of the effort and current statutes, executive orders, or other current Government-wide guidelines.

(ii) Proposers should include a brief description of the organization, its facilities, and previous work experience in the field of the proposal. Identify the cognizant Government audit agency, inspection agency, and administrative contracting officer, when applicable.

(d) **Renewal Proposals.**

(1) Renewal proposals for existing awards will be considered in the same manner as proposals for new endeavors. A renewal proposal should not repeat all of the information that was in the original proposal. The renewal proposal should refer to its predecessor, update the parts that are no longer current, and indicate what elements of the research are expected to be covered during the period for which support is desired. A description of any significant findings since the most recent progress report should be included. The renewal proposal should treat, in reasonable detail, the plans for the next period, contain a cost estimate, and otherwise adhere to these instructions.

(2) NASA may renew an effort either through amendment of an existing contract or by a new award.

(e) **Length.** Unless otherwise specified in the NRA, effort should be made to keep proposals as brief as possible, concentrating on substantive material. Few proposals need exceed 15-20 pages. Necessary detailed information, such as reprints, should be included

as attachments. A complete set of attachments is necessary for each copy of the proposal. As proposals are not returned, avoid use of "one-of-a-kind" attachments.

(f) **Joint Proposals.**

(1) Where multiple organizations are involved, the proposal may be submitted by only one of them. It should clearly describe the role to be played by the other organizations and indicate the legal and managerial arrangements contemplated. In other instances, simultaneous submission of related proposals from each organization might be appropriate, in which case parallel awards would be made.

(2) Where a project of a cooperative nature with NASA is contemplated, describe the contributions expected from any participating NASA investigator and agency facilities or equipment which may be required. The proposal must be confined only to that which the proposing organization can commit itself. "Joint" proposals which specify the internal arrangements NASA will actually make are not acceptable as a means of establishing an agency commitment.

(g) **Late Proposals.** Proposals or proposal modifications received after the latest date specified for receipt may be considered if a significant reduction in cost to the Government is probable or if there are significant technical advantages, as compared with proposals previously received.

(h) **Withdrawal.** Proposals may be withdrawn by the proposer at any time before award. Offerors are requested to notify NASA if the proposal is funded by another organization or of other changed circumstances which dictate termination of evaluation.

(i) **Evaluation Factors.**

(1) Unless otherwise specified in the NRA, the principal elements (of approximately equal weight) considered in evaluating a proposal are its relevance to NASA's objectives, intrinsic merit, and cost.

(2) Evaluation of a proposal's relevance to NASA's objectives includes the consideration of the potential contribution of the effort to NASA's mission.

(3) Evaluation of its intrinsic merit includes the consideration of the following factors of equal importance:

(i) Overall scientific or technical merit of the proposal or unique and innovative methods, approaches, or concepts demonstrated by the proposal.

(ii) Offeror's capabilities, related experience, facilities, techniques, or unique combinations of these which are integral factors for achieving the proposal objectives.

(iii) The qualifications, capabilities, and experience of the proposed principal investigator, team leader, or key personnel critical in achieving the proposal objectives.

(iv) Overall standing among similar proposals and/or evaluation against the state-of-the-art.

(4) Evaluation of the cost of a proposed effort may include the realism and reasonableness of the proposed cost and available funds.

(j) **Evaluation Techniques.** Selection decisions will be made following peer and/or scientific review of the proposals. Several evaluation techniques are regularly used within NASA. In all cases proposals are subject to scientific review by discipline specialists in the area of the proposal. Some proposals are reviewed entirely in-house, others are evaluated by a combination of in-house and selected external reviewers, while yet others are subject to the full external peer review technique (with due regard for conflict-of-interest and protection of proposal information), such as by mail or through assembled panels. The

final decisions are made by a NASA selecting official. A proposal which is scientifically and programmatically meritorious, but not selected for award during its initial review, may be included in subsequent reviews unless the proposer requests otherwise.

(k) **Selection for Award.**

(1) When a proposal is not selected for award, the proposer will be notified. NASA will explain generally why the proposal was not selected. Proposers desiring additional information may contact the selecting official who will arrange a debriefing.

(2) When a proposal is selected for award, negotiation and award will be handled by the procurement office in the funding installation. The proposal is used as the basis for negotiation. The contracting officer may request certain business data and may forward a model award instrument and other information pertinent to negotiation.

(l) **Additional Guidelines Applicable to Foreign Proposals and Proposals Including Foreign Participation.**

(1) NASA welcomes proposals from outside the U.S. However, foreign entities are generally not eligible for funding from NASA. Therefore, unless otherwise noted in the NRA, proposals from foreign entities should not include a cost plan unless the proposal involves collaboration with a U.S. institution, in which case a cost plan for only the participation of the U.S. entity must be included. Proposals from foreign entities and proposals from U.S. entities that include foreign participation must be endorsed by the respective government agency or funding/sponsoring institution in the country from which the foreign entity is proposing. Such endorsement should indicate that the proposal merits careful consideration by NASA and, if the proposal is selected, sufficient funds will be made available to undertake the activity as proposed.

(2) All foreign proposals must be typewritten in English and comply with all other submission requirements stated in the NRA. All foreign proposals will undergo the same evaluation and selection process as those originating in the U.S. All proposals must be received before the established closing date. Those received after the closing date will be treated in accordance with paragraph (g) of this provision. Sponsoring foreign government agencies or funding institutions may, in exceptional situations, forward a proposal without endorsement if endorsement is not possible before the announced closing date. In such cases, the NASA sponsoring office should be advised when a decision on endorsement can be expected.

(3) Successful and unsuccessful foreign entities will be contacted directly by the NASA sponsoring office. Copies of these letters will be sent to the foreign sponsor. Should a foreign proposal or a U.S. proposal with foreign participation be selected, NASA's Office of External Relations will arrange with the foreign sponsor for the proposed participation on a no-exchange-of-funds basis, in which NASA and the non-U.S. sponsoring agency or funding institution will each bear the cost of discharging their respective responsibilities.

(4) Depending on the nature and extent of the proposed cooperation, these arrangements may entail:

(i) An exchange of letters between NASA and the foreign sponsor; or

(ii) A formal Agency-to-Agency Memorandum of Understanding (MOU).

(m) **Export Control Guidelines Applicable to Foreign Proposals and Proposals Including Foreign Participation.**

(1) Foreign proposals and proposals including foreign participation must include a section discussing compliance with U.S. export laws and regulations, e.g., 22 CFR Parts 120-130 and 15 CFR Parts 730-774, as applicable to the circumstances surrounding the particular foreign participation. The discussion must describe in detail the proposed foreign participation and is to include, but not limited to, whether or not the foreign participation may require the prospective proposer to obtain the prior approval of the Department of State or the Department of Commerce via a technical assistance agreement or an export license, or whether a license exemption/exception may apply. If prior approvals via licenses are necessary, discuss whether the license has been applied for or if not, the projected timing of the application and any implications for the schedule. Information regarding U.S. export regulations is available at http://www.pmdtc.org and http://www.bxa.doc.gov. Proposers are advised that under U.S. law and regulations, spacecraft and their specifically designed, modified, or configured systems, components, and parts are generally considered "Defense Articles" on the United States Munitions List and subject to the provisions of the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120-130.

(n) Cancellation of NRA.

(1) NASA reserves the right to make no awards under this NRA and to cancel this NRA. NASA assumes no liability for canceling the NRA or for anyone's failure to receive actual notice of cancellation.

(End of provision)

Appendix C
Proposal Cover Sheet

NASA Research Announcement 00-OES-09
Proposal No. _____ (Leave Blank for NASA Use)

Title: _____

Principal Investigator: _____

Department: _____

Institution: _____

Street/PO Box: _____

City: _____ State: _____ Zip: _____

Country: _____ Congressional District: _____
(used for database sorting purposes only)

E-mail: _____

Telephone: _____ Fax: _____

Co-Investigators:

Name	Institution & Email Address	Address & Telephone
_____	_____	_____
_____	_____	_____
_____	_____	_____

Budget:
1st Year: _____ 2nd Year: _____ 3rd Year: _____ Total: _____

Certification of Compliance with Applicable Executive Orders and U.S. Code

By submitting the proposal identified in this *Cover Sheet/Proposal Summary* in response to this Research Announcement, the Authorizing Official of the proposing institution (or the individual proposer if there is no proposing institution) as identified below:

- certifies that the statements made in this proposal are true and complete to the best of his/her knowledge;
- agrees to accept the obligations to comply with NASA award terms and conditions if an award is made as a result of this proposal; and
- confirms compliance with all provisions, rules, and stipulations set forth in the two Certifications contained in this NRA [namely, (i*) Certification of Compliance with the NASA Regulations Pursuant to Nondiscrimination in Federally Assisted Programs, and*
(ii) Certifications, Disclosures, And Assurances Regarding Lobbying and Debarment & Suspension].

Willful provision of false information in this proposal and/or its supporting documents, or in reports required under an ensuing award, is a criminal offense (U.S. Code, Title 18, Section 1001).

Title of Authorizing Institutional Official: _____

Signature: _____ Date: _____

Name of Proposing Institution: _____

Telephone: _____ E-mail: _____ Facsimile: _____

Certification of Compliance with the NASA Regulations Pursuant to Nondiscrimination in Federally Assisted Programs

The *(Institution, corporation, firm, or other organization on whose behalf this assurance is signed, hereinafter called "Applicant ")* hereby agrees that it will comply with Title VI of the Civil Rights Act of 1964 (P.L. 88-352), Title IX of the Education Amendments of 1962 (20 U.S.C. 1680 et seq.), Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. 794), and the Age Discrimination Act of 1975 (42 U.S.C. 16101 et seq.), and all requirements imposed by or pursuant to the Regulation of the National Aeronautics and Space Administration (14 CFR Part 1250) (hereinafter called "NASA") issued pursuant to these laws, to the end that in accordance with these laws and regulations, no person in the United States shall, on the basis of race, color, national origin, sex, handicapped condition, or age be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity for which the Applicant receives federal financial assistance from NASA; and hereby give assurance that it will immediately take any measure necessary to effectuate this agreement.

If any real property or structure thereon is provided or improved with the aid of federal financial assistance extended to the Applicant by NASA, this assurance shall obligate the Applicant, or in the case of any transfer of such property, any transferee, for the period during which the real property or structure is used for a purpose for which the federal financial assistance is extended or for another purpose involving the provision of similar services or benefits. If any personal property is so provided, this assurance shall obligate the Applicant for the period during which the federal financial assistance is extended to it by NASA.

This assurance is given in consideration of and for the purpose of obtaining any and all federal grants, loans, contracts, property, discounts, or other federal financial assistance extended after the date hereof to the Applicant by NASA, including installment payments after such date on account of applications for federal financial assistance which were approved before such date. The Applicant recognized and agrees that such federal financial assistance will be extended in reliance on the representations and agreements made in this assurance, and that the United States shall have the right to seek judicial enforcement of this assurance. This assurance is binding on the Applicant, its successors, transferees, and assignees, and the person or persons whose signatures appear below are authorized to sign on behalf of the Applicant.

NASA FORM 1206

CERTIFICATIONS, DISCLOSURES, AND ASSURANCES REGARDING LOBBYING AND DEBARMENT & SUSPENSION

1. LOBBYING

As required by Section 1352, Title 31 of the U.S. Code, and implemented at 14 CFR Part 1271, as defined at 14 CFR Subparts 1271.110 and 1260.117, with each submission that initiates agency consideration of such applicant for award of a Federal contract, grant, or cooperative agreement exceeding $ 100,000, the applicant must **certify** that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit a Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

2. GOVERNMENTWIDE DEBARMENT AND SUSPENSION

As required by Executive Order 12549, and implemented at 14 CFR 1260.510, for prospective participants in primary covered transactions, as defined at 14 CFR Subparts 1265.510 and 1260.117—

(1) The prospective primary participant **certifies** to the best of its knowledge and belief, that it and its principals:

(a) Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded by any Federal department or agency.

(b) Have not within a three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property;

(c) Are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State or local) with commission of any of the offenses enumerated in paragraph (l)(b) of this certification; and

(d) Have not within a three-year period preceding this application/proposal had one or more public transactions (Federal, State or local) terminated for cause or default.

(2) Where the prospective primary participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

Appendix D
Budget Summary

For period from _____ to _____

• Provide a complete Budget Summary for year one and separate estimates for each subsequent year.
• Enter the proposed estimated costs in Column A (Columns B & C for NASA use only).
• Provide as attachments detailed computations of all estimates in each cost category with narratives as required to fully explain each proposed cost. See *Instructions For Budget Summary* on following page for details.

		NASA USE ONLY	
	A	**B**	**C**
1. Direct Labor (salaries, wages, and fringe benefits)			
2. Other Direct Costs:			
a. Subcontracts			
b. Consultants			
c. Equipment			
d. Supplies			
e. Travel			
f. Other			
3. Facilities and Administrative Costs			
4. Other Applicable Costs:			
5. SUBTOTAL--Estimated Costs			
6. Less Proposed Cost Sharing (if any)			
7. Carryover Funds (if any)			
a. Anticipated amount : _____			
b. Amount used to reduce budget			
8. Total Estimated Costs			
9. APPROVED BUDGET			

Instructions for Budget Summary

1. Direct Labor (salaries, wages, and fringe benefits): Attachments should list the number and titles of personnel, amounts of time to be devoted to the grant, and rates of pay.

2. Other Direct Costs:
    a. Subcontracts: Attachments should describe the work to be subcontracted, estimated amount, recipient (if known), and the reason for subcontracting.
    b. Consultants: Identify consultants to be used, why they are necessary, the time they will spend on the project, and rates of pay (not to exceed the equivalent of the daily rate for Level IV of the Executive Schedule, exclusive of expenses and indirect costs).
    c. Equipment: List separately. Explain the need for items costing more than $5,000. Describe basis for estimated cost. General-purpose equipment is not allowable as a direct cost unless specifically approved by the NASA Grant Officer. Any equipment purchase requested to be made as a direct charge under this award must include the equipment description, how it will be used in the conduct of the basic research proposed and why it cannot be purchased with indirect funds.
    d. Supplies: Provide general categories of needed supplies, the method of acquisition, and the estimated cost.
    e. Travel: Describe the purpose of the proposed travel in relation to the grant and provide the basis of estimate, including information on destination and number of travelers where known.
    f. Other: Enter the total of direct costs not covered by 2a through 2e. Attach an itemized list explaining the need for each item and the basis for the estimate.

3. Facilities and Administrative (F&A) Costs: Identify F&A cost rate(s) and base(s) as approved by the cognizant Federal agency, including the effective period of the rate. Provide the name, address, and telephone number of the Federal agency official having cognizance. If unapproved rates are used, explain why, and include the computational basis for the indirect expense pool and corresponding allocation base for each rate.

4. Other Applicable Costs: Enter total explaining the need for each item.

5. Subtotal-Estimated Costs: Enter the sum of items 1 through 4.

6. Less Proposed Cost Sharing (if any): Enter any amount proposed. If cost sharing is based on specific cost items, identify each item and amount in an attachment.

7. Carryover Funds (if any): Enter the dollar amount of any funds expected to be available for carryover from the prior budget period Identify how the funds will be used if they are not used to reduce the budget. NASA officials will decide whether to use all or part of the anticipated carryover to reduce the budget (not applicable to 2nd-year and subsequent-year budgets submitted for award of a multiple year award).

8. Total Estimated Costs: Enter the total after subtracting items 6 and 7b from item 5.